VHDL SIMULATION: AN EFFECTIVE TECHNIQUE FOR IMAGE COMPRESSION

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ABSTRACT : *In today's world of electronics and the ever rising usage of multimedia gadgets gives rise to the generation of large amount of data and images .these images and data need to be sent at a higher speed and high transferred rate. To overcome these problem , image compression has proven to be an excellent tool since no loss of data can be compromised. The paper propose a technique to achieve image compression using Linde , Buzo & Gray algorithm . the basic requirement of lbg algorithm is nothing but generation of code book. Code book Is collection of no of codeword . Linde, Buzo & gray algorithm is associated with the vector quantization . In this paper we propose a technique to achieve image compression with the use of VHDL simulation. The achieved compression can be successfully evaluated using compression ratio (CR) and the distortion in the decoded image can be determined using peak signal to noise ratio (PSNR)*

Keywords -:Compression Ratio, Distortion, Image Compression , LBG Algorithm , Vector Quantization , Peak Signal To Noise Ratio, Decoded.

1. INTRODUCTION

Main aim of Image compression is to achieve reduction but there should be no loss in the data can be compromised. Image compression reduces bit rate for transmission or data storage and also maintains acceptable fidelity or image quality. Image compression can be achieved using two image compression schemes defined as below :-

1) Lossless Image Compression scheme.
2) Lossy Image compression scheme.

Lossy Image compression scheme is further classified as :-

1) Scalar Quantization (SQ)
2) Vector Quantization (VQ)

Lossless image compression scheme can be defined as a scheme where the image can be reconstructed after compression, without loss of data in the entire process. The image compression and decompression is identical to original image and every bit of information is preserved under decomposition process. Reconstructed image is the replica of the original image..In this scheme, no loss of data can be compromised. It can be used for document and medical imaging. *Lossy* techniques, on the other hand are irreversible, because, they involve performing Quantization, which result in loss of data. *Lossy compression* can be used for signals like natural images, speech [1]etc, where the amount of loss in the data determines the quality of the reconstruction and does not lead to change in the information content. Reconstructed image contains degradation with respect to its original image. There are small amount of redundancies present. It can be used for multimedia applications. Every digital image is specified by the number of pixels associated with the image each pixel in an image can be denoted as a coefficient, which represents the intensity of the image at that point. Once compressed, the coded image is transferred to the receiving end, where these compressed images are again decompressed to recover the original image[4].

The most powerful and quantization technique used for the image compression is vector quantization(VQ).The vector quantization algorithms for reducing the transmission bit rate or storage have been extensively investigated for speech and image signals. Image vector quantization (VQ) includes four stages: vector formation, Training set selection, codebook generation and quantization. The first step is to divide the input image into set of vectors. The Subset of vectors in the set is later chosen as a training sequence. The codebook of code words is obtained by an iterative clustering algorithm. Finally, in quantizing an input vector, closest code words in the codebook is determined and corresponding label of this code word is transmitted. In this process, data compression is achieved because address transmission requires fewer bits than transmitting vector itself. The concept of data quantization is extended from scalar to vector data of arbitrary dimension. Instead of output levels, vector quantization employs a set of representation vectors (for one dimensional case) or matrices (for two dimensional cases). Set is defined as "codebook" and entries as "code words". Vector quantization has been found to be an efficient coding technique due to its inherent ability to exploit the high correlation between the neighboring pixels [4]

Vector quantization is often used when high compression ratio are required. Any compression algorithm is acceptable provided a corresponding decompression algorithm exits. Vector Quantization(VQ) achieves more compression than scalar quantization, making it useful for band-limited channels. Numerous compression techniques have been developed such as vector quantization, block truncation method ,transform coding ,hybrid coding and various adaptive versions of this methods. Among these techniques, vector Quantization is widely used in image compression owing to its simple structure and low bit rate. In the process of vector Quantization the image to be encoded is segmented into a set of input image vectors. The most important task for the VQ scheme is to design a good codebook. A good codebook is required because the reconstructed image highly depends on the code words in this very codebook. The generated codebook store into text file for vhdl file handling or data array in vhdl code. The algorithm for the design of optimal VQ is commonly referred to as the Linde-Buzo-Gray(LBG) algorithm, and it is based on minimization of the squared-error distortion measure. In 1980, Linde, Buzo, and Gray proposed the VQ scheme for grayscale image compression and it has proven to be a powerful tool for both speech and digital image compression. There are three major procedures in VQ, namely codebook generation, encoding procedure and decoding procedure. In the codebook generation process, various images are divided into several k-dimension training vectors. The representative codebook is generated from these training vectors by the clustering techniques. In the encoding procedure, an original image is divided into several k-dimension vectors and each vector is encoded by the index of codeword by a table look-up method. The encoded results are called an index table [6].

2. PROPOSED TECHNIQUE

The LBG algorithm is the most cited and widely used algorithm on designing the VQ codebook. It is the starting point for most of the work on vector quantization. The performance of the LBG algorithm is extremely dependent on the selection of the initial codebook. In conventional LBG algorithm, the initial codebook is chosen at random from the training data set. It is observed that some-time it produces poor quality codebook. Due to the bad codebook initialization, it always converges to the nearest local minimum. This problem is called the local optimal problem . In addition, it is observed that the time required to complete the iterations depends upon how good the initial codebook is. In literature, several initialization techniques have been reported for obtaining a better local minimum. The concept of VQ is based on Shannon"s rate-distortion theory where it says that the better compression is always achievable by encoding sequences of input samples rather than the input samples one by one. In VQ based image compression, initially image is decomposed into non over lap-ping sub image blocks. Each sub block is then converted into one-dimension vector which is termed as training vector. From all these training vectors, a set of representative vectors are selected to represent the entire set of training vectors [6]. As stated earlier, the VQ process is done in the following three steps namely (i) codebook design, (ii) encoding process and (iii) decoding process. An initial code vector is set as average of entire training sequence is later on split to provide 2 code vectors. These are further split to double themselves and the process is repeated to procure the desired number. An identical codebook previously generated is required in both the encoding procedure and the decoding procedure in VQ scheme. In the process of vector quantization, the image to be encoded is segmented into set of input image vectors. In the encoding procedure, the closest codeword for each input vector is chosen, and its index is transmitted to the receiver. In the decoding procedure, a simple table look- up procedure is done to reconstruct the encoded image in the receiver. Thus, the encoded image of the original input image becomes available to the receiver. The whole compression process is accomplished when the encoded image is reconstructed with the corresponding index of each input image vector.

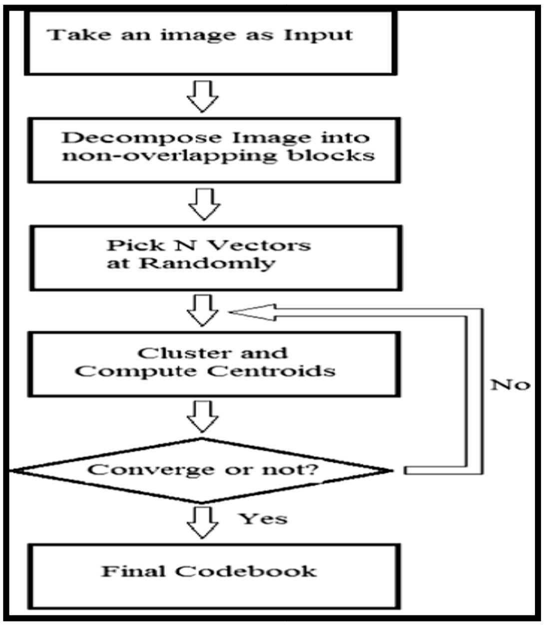


Figure 1: The flowchart of LBG clustering algorithm.

The flowchart of LBG clustering algorithm is shown in Figure 1. After codebook design process, each codeword of the codebook is assigned a unique index value. Then in the encoding process, any arbitrary vector corresponding to a block from the image under consideration is replaced by the index of the most appropriate representative codeword. The matching is done based on the computation of minimum squared Euclidean distance between the input training vector and the codeword from the codebook. So after encoding process, an index table is produced.

The codebook and the index-table is nothing but the compressed form of the input image. In decoding process, the codebook which is available at the receiver end too, is employed to translate the index back to its corresponding codeword. This decoding process is simple and straight forward. shows the schematic diagram of VQ encoding-decoding process [5]. LBG is an easy and rapid algorithm. However, it has the local optimal problem which is that for a given initial solution, it always converges to the nearest local minimum. In other words, LBG is a local optimization procedure [6]. The objective of our project is to compress the image using the Linde, Buzo, and Gray (LBG) Algorithm. The algorithm can be explained using few simple steps :-

Step 1. First, you find the sample mean $z1$ (1) for the entire data set. Here we have only one prototype. The sample mean is proven total mean square distortion. For a single prototype.

Step 2. Set $k = 1$, $l = 1$. l is the index for the iteration. k counts the number of prototypes that have been generated.Here we have only one prototype.

Step 3. If $k < M$, split the current centroids by adding small offsets. Since if we already have k prototypes, we need $M - k$ additional prototypes. If $M – K \geq K$, Split all the existing centroids that have been created so far; otherwise we split only M – K of them.

Step 4. For example, to split $z1$ (1) into two centroids, let $z1$ (2) = $z1$ (1), $z2$ (2) = $z1$ (1) + ε, where ε is a small offset.

Step 5. Use {$z1$ (1), $z2$ (1), ... , zk (1)} as initial prototypes, which includes the previously generated centroids and the newly split centroids.

Step 6. Check whether the number of prototypes has reached the target number of prototypes. In other words, if $k < M$, go back to step 3; otherwise, stop.

3. System Architecture.

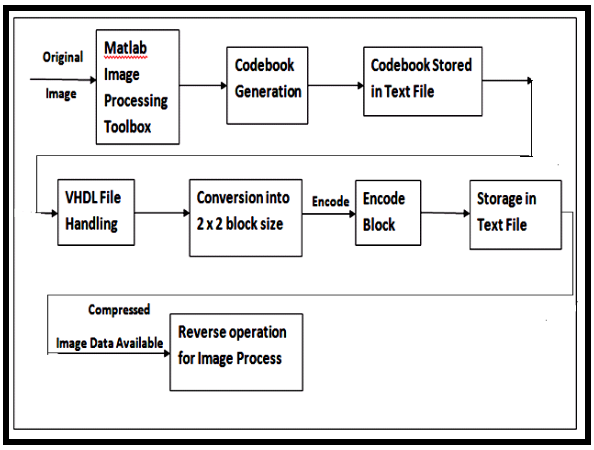


Figure 2 : System Architecture.

The performance of VQ based image compression techniques depends upon the constructed codebook. Hence, for the VQ codebook design we use LBG algorithm. However, the performance of the standard LBG algorithm is highly dependent on the choice of initial codebook. The algorithm requires an initial codebook to start with. For this purpose we use MATLAB image processing toolbox for codebook generation.

Generated codebook stored into text file for VHDL file handling or data array in VHDL code. Input provided is the grey image which is read in MATLAB and stored into text file for VHDL file handling. The complete available image is converted into 2 X 2 Block size. Now, in the encoding process any arbitrary vector corresponding to a block from the image under consideration is replaced by the index of the most appropriate representative codeword. The matching is done on the basis of the computation of minimum squared Euclidean distance. Between the i/p training vector and the codeword from the codebook. So, after encoding process an index table is produced. The codebook and index-table is nothing but compressed form of input image (7).

In the reverse process, we perform reverse operation. This process is simple and straight forward where compressed image data is available. Algorithm works on gray image and the nature of code will be of Non-synthesis type as it uses file handling input is in the form of image

The algorithm can be evaluated in terms of compression ratio (CR) and peak signal to noise ratio (PSNR). The compression ratio and peak signal to noise ratio are defined along with their mathematical formula and are given as under:- Compression ratio is defined as ratio of the number of bits required to represent the data before compression to the number of bits required after compression. (12)

Mathematically, Compression ratio (%) =

No of bits required before compression

No of bits required after compression

Peak signal to noise ratio(PSNR) is defined as ratio of square the peak value of the signal to the mean square error. Where, mean square error refers to the average value of the square of the error between the original image f(m,n) and the reconstruction image g(m,n). A common measure of distortion is the mean square error (MSE). (12) Mathematicaly,

$$MSE = \frac{1}{M \times N} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} \Sigma \left(f(m,n) - g(m,n) \right)2$$

M × N represents the size of the image.

The distortion in the decoded images is measured using peak signal to noise ratio, (12)

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) dB$$

4. APPLICATIONS:-

1) A good example to illustrate this is the health industry, where the constant scanning and/or storage of medical images and documents take place. Image compression offers many other benefits, as information can be stored without placing large loads on system servers Depending on the type of compression applied, images can be compressed to save storage space, or to send to multiple physicians for examination. And conveniently, these images can uncompress when they are ready to be viewed, retaining the original high quality and detail that medical imagery demands.

2) Image compression also plays an important role to any organization that requires the viewing and storing of images to be standardized, such as a chain of retail stores or a federal government agency. In the retail store example, the introduction and placement of new products or the removal of discontinued items can be much more easily completed when all employees receive, view and process images in the same way.

3) Federal government agencies that standardize their image viewing, storage and transmitting processes can eliminate large amounts of time spent in explanation and problem solving. The time they save can then be applied to issues within the organization, such as the improvement of government and employee programs.[8]

Regardless of industry, image compression has virtually endless benefits wherever improved storage, viewing and transmission of image are required. [8]

5. CONCLUSION AND FUTURE SCOPE:-

Conclusion:-

Above proposed algorithm reduces the complexity of a transferred image, without sacrificing performance. The LBG algorithm is highly dependent upon the codebook generation. It is an easy, rapid, efficient & simple algorithm which saves computation time & cost. Hence, we have used Linde, Buzo and gray algorithm along with VHDL simulation for image compression.

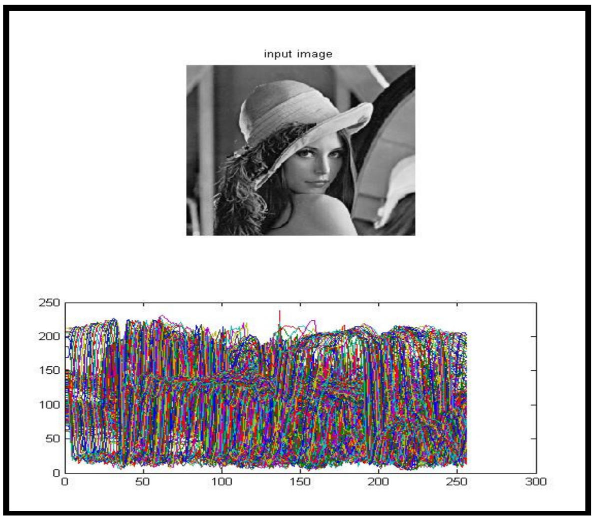
Future Scope:-

LBG has the local optimal problem for a given initial solution, it always converges to the nearest local minimum.

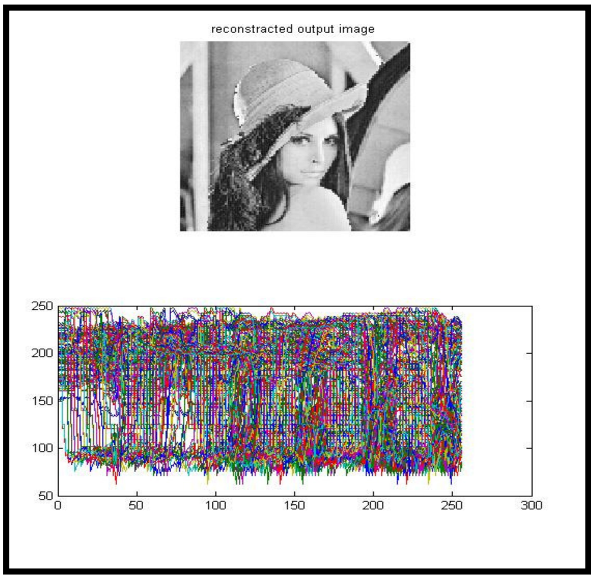
The other problem is that generation of codebook is a complex task. It needs more storage capacity for codebook. Convergence time is also very large.

The future enhancement primarily focuses on developing vector quantization algorithm that may ensure less storage space, less transfer time and less image viewing and loading time.

6. Result:-



Input Image and Its Plot



Reconstructed Image and Its Plot

Table					
Compression measure are shown					
Image	Codebook Size	Bits used	C.R	MSE	PSNR
Leena	128	7	4:1	1.369	46.806

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